Washington State Department of Transportation

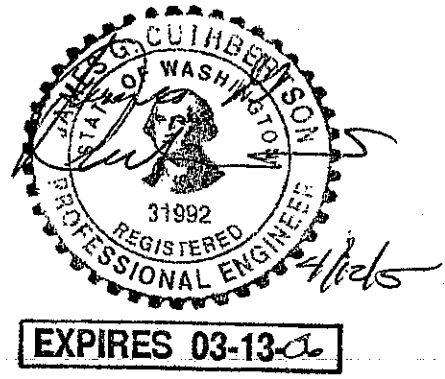
Memorandum

April 11, 2005

TO: Terry L. Mattson/ James Reynolds
NC Region Project Office, Wenatchee

FROM: T.M. Allen/D.A. Williams
E&EP Geotechnical Branch, 47365

SUBJECT: SR-28, XL-1217
East Wenatchee 31st to Hadley
Box Culvert Replacement, MP 0.78
Geotechnical Recommendations



EXPIRES 03-13-06

This report presents geotechnical information for the replacement of an existing culvert in the vicinity of MP 0.78 on SR 28 north of East Wenatchee. A vicinity map is provided as Figure A-1. The existing culvert will be replaced and extended for existing canal crossing under SR 28. The proposed new culvert will be a four sided box culvert, which is approximately 85 ft long, and will have a span of 6 ft with a rise of 4 ft. The culvert will have up to 3.4 ft of cover. When the work is completed, this section of SR 28 will conform to the current roadway standards.

The analyses, conclusions and recommendations presented in this report are based on the project description and site conditions existing at the time of the field explorations. We assume that the exploratory borings represent the subsurface conditions in the project area. If different subsurface conditions are encountered or appear to be present during construction, we should be contacted so that we can reevaluate our conclusions and recommendations and assist you.

Exploration Program

Two test holes were drilled along the culvert to assess foundation soil conditions. The test hole locations are shown on Figure A-2 in Appendix A. Standard Penetration Tests (SPT) were performed at 5-foot intervals. Disturbed soil samples from the SPT were visually classified. The samples were then transmitted to E&EP Materials Lab for further examination and laboratory testing. Test hole logs, H-1-01 and H-2-01, are included in Appendix B.

Laboratory Testing

Laboratory testing performed on selected samples from the field exploration program. The testing consisted of performing particle size analyses, determining the liquid limit if applicable, and determining the plastic limit and plasticity index if applicable. The tests were done in accordance with AASHTO T-88, T-89, and T-90 guide specifications respectively. After the testing was completed, the samples were classified using the Unified Soil Classification System (USCS).

The results of all laboratory testing are summarized in Appendix C.

Site Conditions

The soils encountered during the field investigation have been grouped into three general soil units based on engineering properties and material classifications. The units are briefly described below:

Unit 1 Medium dense to loose, silty sand with gravel.

Unit 2 Medium dense well-graded to poorly graded gravel with silt and sand.

Unit 3 Medium dense to dense poorly graded sand with silt.

A typical soil profile is shown in Figure A-3 in Appendix A. Copies of the test hole logs with current stationing are included as attachments in Appendix B.

It is our understanding that the existing canal has a clay liner. On similar culvert crossings, a minimum of 1.0 feet of the clay was encountered below the old culverts. The clay has been reported to contaminate the native soil to a depth of 3 feet below the proposed culvert flow line.

Ground Water

Ground water was encountered in test holes H-1-01 and H-2-01 over 20 feet below the canal at the time of drilling. We expect that the ground water will vary with the seasonal fluctuations of the canal level. Ground water observations are included on the test hole logs.

Design Recommendations

Culvert Design

It is our understanding that the Design Office prefers a four-sided precast reinforced box culvert. Since the culvert is skewed approximately 47 ° from the perpendicular of the roadway alignment, the culvert will likely require a special design due to the shape of the culvert end sections. We were asked to provide foundation design information to be provided to the contractor. Special design culverts will require both Bridge and Structures and Hydraulics approval. Their review is also required if precast culverts are used.

The base of the culvert can be designed for an allowable bearing pressure of up to 2,000 psf. We estimate a total settlement of less than 1-inch will occur beneath the culvert extension. Settlement is expected to be negligible where the existing roadway embankment has preloaded the soils. However, differential settlement up to 0.5 inches may occur between the end of the culvert extention and the edge of the existing roadway shoulder. The settlement should be uniform between each side of the culvert. The majority of the settlement should occur as the fill is placed. Post construction settlement should be negligible.

The plans show an existing storm water sewer line near the western end of the new culvert. It is our understanding this line is sleeved with a larger diameter pipe that can handle some deflection due to added fill above the line. We estimated that as much as 0.25 inches of settlement will occur on the water line due the additional load of the new culvert.

For the passive pressure resistance at the foundation base and the active pressure acting on the sides of the culvert, the soil properties provided in Table 1 should be used to estimate the forces. Please note that these values are ultimate values. For load factor design, a factor of safety is applied to both the passive earth pressure coefficient (K_p) and coefficient of sliding (tan ϕ_f) values. Typically the passive earth pressure is factored by 1.5, K_p /1.5.

Table 1: Soil Properties

Parameter	Abutment Piers
Unit Weight, γ	125 pcf
Soil Friction Angle, ϕ'_f	35°
Active Earth Pressure Coefficient, K_a	0.27
At rest Earth Pressure Coefficient, K_o	0.43
Passive Earth Pressure Coefficient, K_p (Flat Ground – Coulomb's Method)	3.7
Seismic Earth Pressure Coefficient, K_{ae}	0.30
Coefficient of Sliding (tan ϕ_f)	0.70

Site Seismicity

Typically WSDOT does not design for seismicity when designing culverts. However, the proprietary culvert manufacture may want some guidance. We are providing the following information: A peak ground acceleration coefficient of 0.11g is recommended for seismic design of the structures on this project in accordance with the 2002 US Geological National Hazard Map. The recommended acceleration coefficient is based on expected peak ground acceleration at the project site that has a 90 percent probability of not being exceeded in a 50-year period. If a detailed seismic design is required, we recommend using the AASHTO Type III soil profile response spectrum and a site coefficient (S) of 1.5.

Construction Considerations

We assume that a proprietary culvert manufacturer will be used, therefore the sizing of the culvert and culvert details are typically determined by the manufacturer of the culvert system to conform to the allowable design stresses and the connection requirements for their system.

We expect the footing excavation will occur under dry foundation conditions. The work will be done after the canal is closed down for the season.

Currently, the design drawings show an over-excavation of approximately 3 feet below the new culvert backfilled with 2 ft of quarry spalls and 1 foot of Crushed Surfacing Base Course, Shoulder Ballast, or Gravel Borrow. The over-excavation is required to remove the suspected clay liner, which may be present under the existing culvert. However, a 3-foot deep over-excavation would only be necessary where we have ground water problems or large structural loads. This level of over-excavation may not be required at this site, as shown in Figure 3. We suspect a minimum working platform of approximately 1-foot of gravel borrow, shoulder ballast, and/or crushed surfacing base course may be all that is required.

The culvert site will be constructed in a relatively confined area. We understand that SR 28 will be closed for a weekend to allow the excavation and placement of the new culvert sections under the roadway. We estimate that the excavation to construct the culvert will be approximately 10 ft deep. The contract may elect to open hole the site to install the new culvert. We recommend using Structure Excavation Class B as a pay item for any excavation below the bottom of the box culvert per Section 2-09.3(2) of the Standard Specifications.

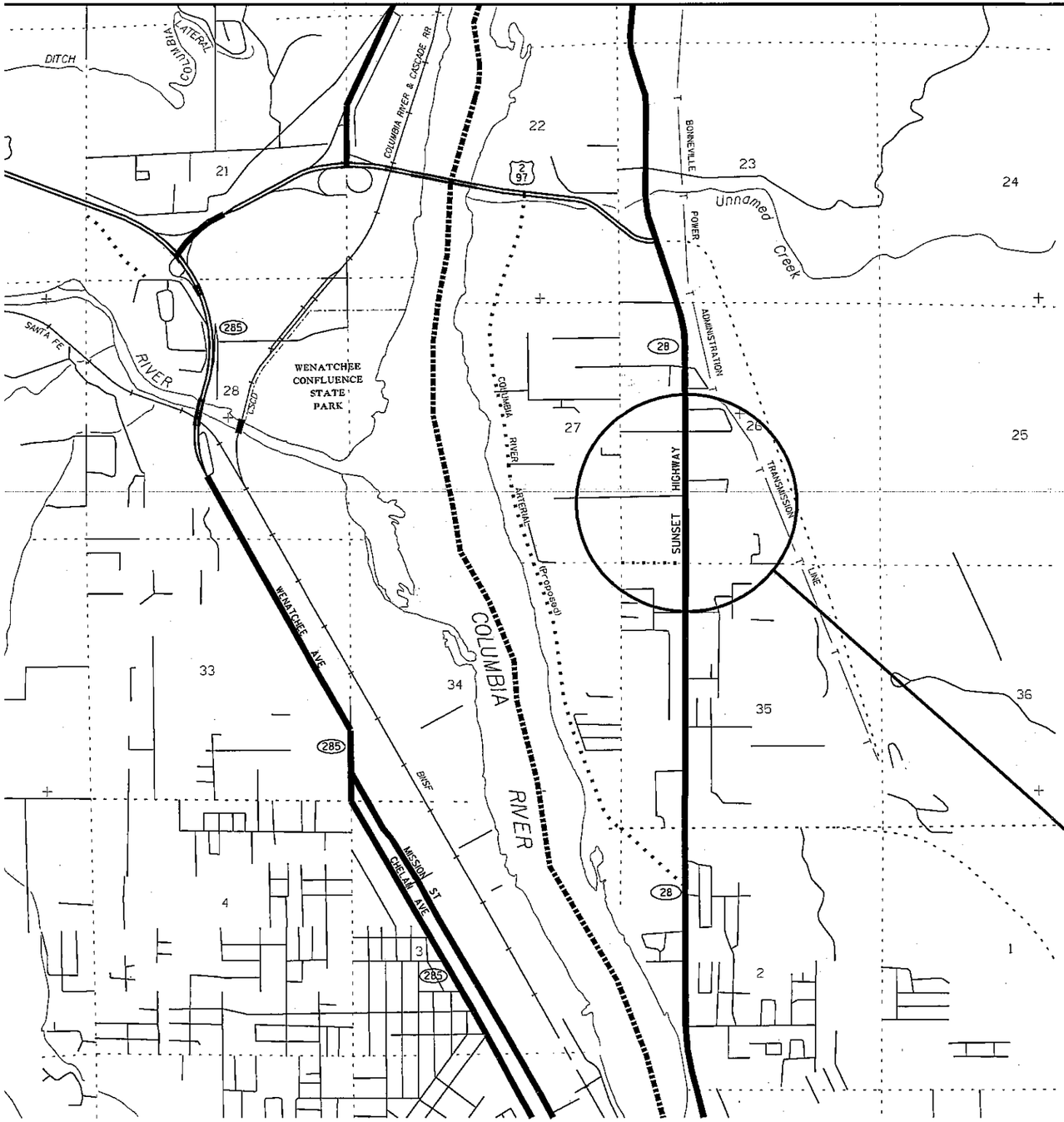
We recommend that a Summary of Geotechnical Conditions be included in the contract documents to identify potential construction difficulties. The Summary of Geotechnical Conditions was forwarded during the PS&E review.

If you have any questions regarding this memorandum, please contact Donald Williams at (360) 709-5457.

TMA:daw
DAW
Attachments

cc: Jerry R. Roseburg, Materials Engineer, NC Region, Wenatchee
Dave Erickson, HQ Roadway Construction, MS 47354
M. J. Witecki, OSC Hydraulics, MS 47329

APPENDIX - A



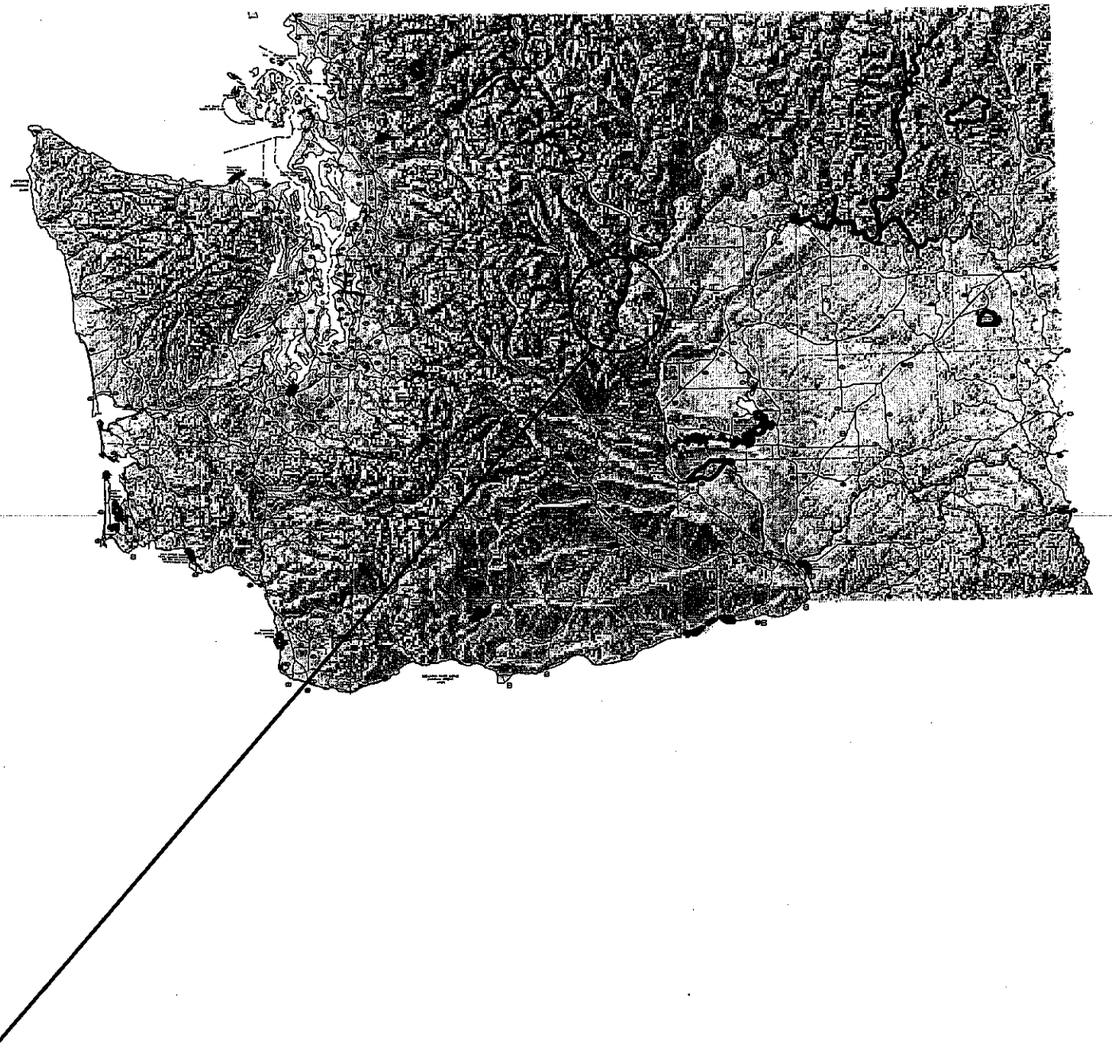


Figure A-1: Site Map

JOB XL-1217 S.R. 28 C.S. _____

East Wenatchee, 31st St. to Hadley Box Culvert Replacement

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH

T. E. BAKER MATERIALS ENGINEER

DATE 4/2005
SCALE N.T.S. VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

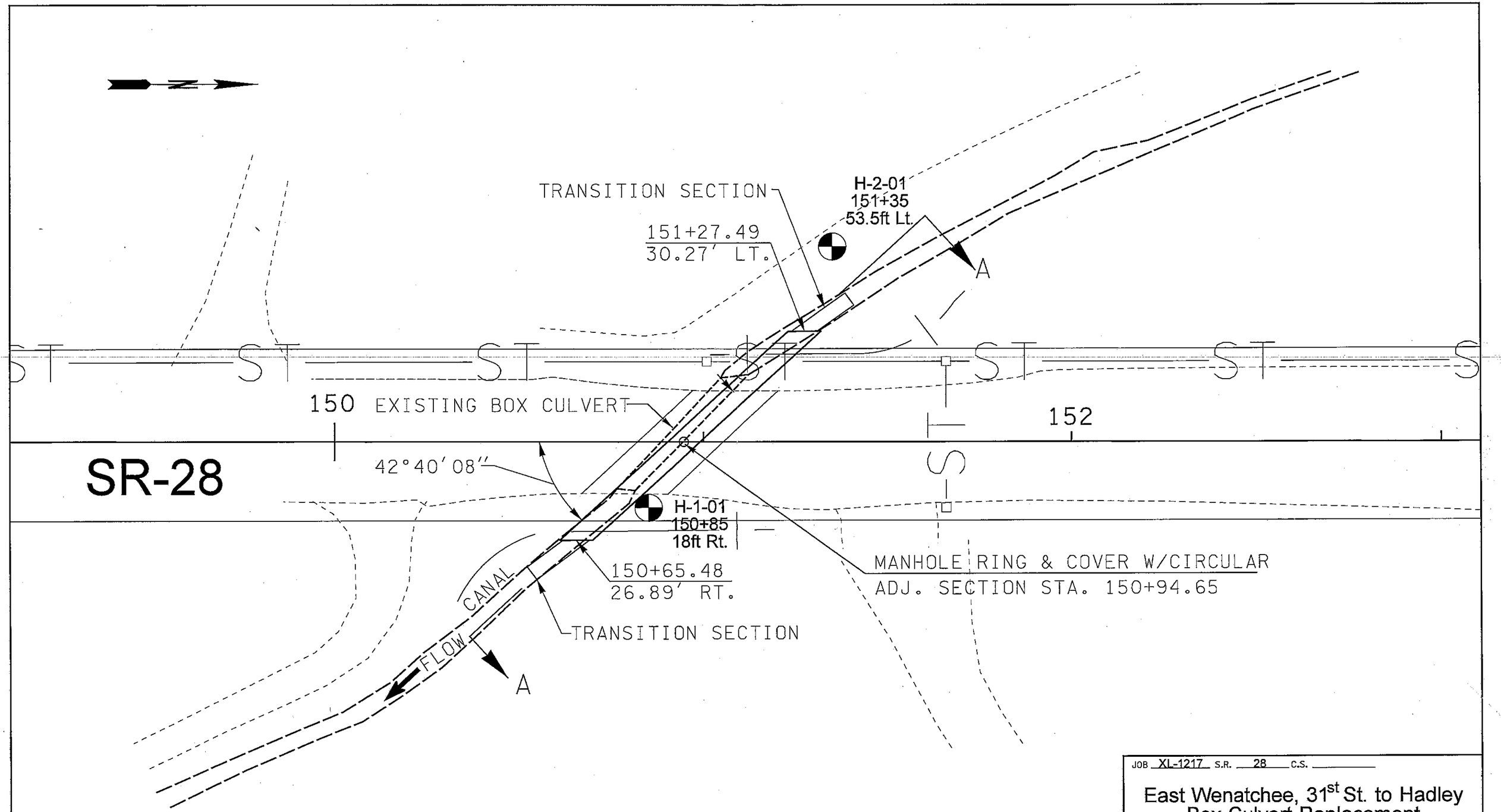


Figure A-2: Test Hole Locations

JOB XL-1217 S.R. 28 C.S. _____

East Wenatchee, 31st St. to Hadley
Box Culvert Replacement

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 4/2005
SCALE 1=25' VERT.
HORIZ.
SHEET ____ OF ____
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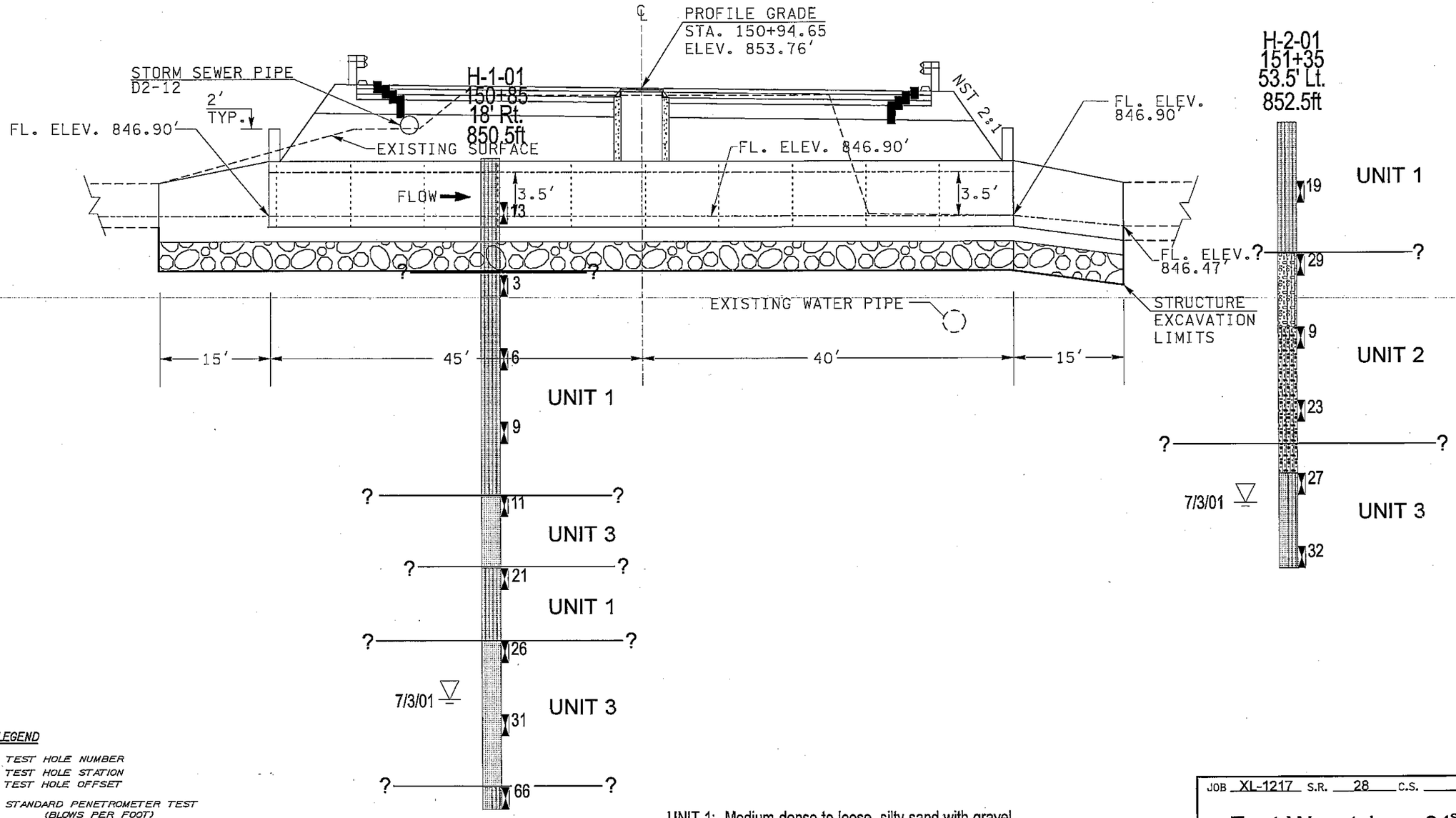

TEST HOLE LEGEND

H-1-04 TEST HOLE NUMBER
110+55 TEST HOLE STATION
26 ft.Rt. TEST HOLE OFFSET
23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
8/5/04 WATER LEVEL & DATE
UNDISTURBED SAMPLE
SOIL/ROCK STRATA AS DEFINED ON BORING LOG
INDICATES CORE SAMPLE TAKEN
100 / 4
ROCK QUALITY DESIGNATION IN %

UNIT 1: Medium dense to loose, silty sand with gravel.

UNIT 2: Medium dense well graded to poorly graded gravel with silt and sand.

UNIT 3: Medium dense to dense poorly graded sand with silt.

Figure A-3: Soil Cross Section

JOB XL-1217 S.R. 28 C.S.

East Wenatchee, 31st St. to Hadley Box Culvert Replacement

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 4/2005
SCALE N.T.S. VERT. HORIZ.
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APPENDIX - B

Logs of Test Borings

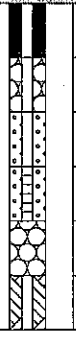
Washington State Department of Transportation

Test Boring Legend

Sampler Symbols

Standard Penetration Test
Oversized Penetration Test (Dames & Moore, California)
Shelby Tube
Piston Sample
Washington Undisturbed
Vane Shear Test
Core
Becker Hammer
Bag Sample

Well Symbols



Cement Surface Seal
Piezometer Pipe in Granular Bentonite Seal
Piezometer Pipe in Sand
Well Screen in Sand
Granular Bentonite Bottom Seal
Inclinometer Casing in Concrete Bentonite Grout

Laboratory Testing Codes

UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
UC	Unconfined Compression Test
DS	Direct Shear Test
CN	Consolidation Test
GS	Grain Size Distribution
MC	Moisture Content
SG	Specific Gravity
OR	Organic Content
DN	Density
AL	Atterberg Limits
PT	Point Load Compressive Test
SL	Slake Test
DG	Degradation
LA	LA Abrasion
HT	Hydrometer Test

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-24	Medium Dense	5-8	Medium Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

Angularity of Gravel & Cobbles

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, somtimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCL Reaction

No HCL Reaction	No visible reaction.
Weak HCL Reaction	Some reaction with bubbles forming slowly.
Strong HCL Reaction	Violent reaction with bubbles forming imediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

Washington State Department of Transportation

Test Boring Legend

Grain Size

Fine Grained	< 1mm	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	1mm to 5mm	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 5mm	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	150-3500 psi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3500-7500 psi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7500-15000 psi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15000-350000 psi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 30000 psi

Discontinuities

Spacing

Very Widely	Greater than 3 m
Widely	1 m to 3 m
Moderately	0.3 m to 1 m
Closely	50 mm to 300 mm
Very Closely	Less than 50 mm

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition

Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 1 mm, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 1 mm, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 5 mm thick, or open discontinuities 1 to 5 mm.
Very Poor	Soft gouge greater than 5 mm thick, or open discontinuities greater than 5 mm.

Fracture Frequency (FF) is the average number of fractures per 300 mm of core.
Does not include mechanical breaks caused by drilling or handling.

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-04731

HOLE No. H-1-01

Sheet 1 of 3

Job No. XL-1217 SR 28 Elevation 850.5 ft (259.2 m)

Project East Wenatchee Canal Crossing-Box Culvert. Driller Fetterly Lic# 2507

Site Address Inspector Hanning

Start July 3, 2001 Completion July 3, 2001 Well ID# NA Equipment CME 850 w/ autohammer

Station 150+85 Offset 18' Rt. Casing HQ Method Wet Rotary

Northing 494724.212 Easting 2101175.686 Latitude Longitude

County Douglas Subsection NW/SW Section 26 Range 20 EWM Township 23N

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			2 3 10 (13)		D-1		Silty SAND with gravel, medium dense, brown, moist, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
5	1								
	2		3 2 1 (3)		D-2	GS MC	SM, MC=21% Silty SAND, very loose, brown, wet, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
10	3								
	4		1 2 4 (6)		D-3		Silty SAND, with some gravel., loose, brown, wet, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
15	5								
			1 3 6 (9)		D-4		Silty SAND, loose, brown, wet, Stratified, no HCl reaction, Note material change at 18.8 to poorly graded sand, moist, stratified. Some silt. Length Recovered 0.9 ft, Length Retained 0.9 ft		
20	6								

SOIL XL-1217 SR-28 EAST WENATCHEE-CANAL.GPJ SOIL.GDT 3/29/05 2:06:15 P3

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-04731

Job No. XL-1217 SR 28 Elevation 850.5 ft (259.2 m)

HOLE No. H-1-01

Sheet 2 of 3

Project East Wenatchee Canal Crossing-Box Culvert.

Driller Fetterly Lic# 2507

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	7			3 4 7 (11)		D-5		Poorly graded SAND, medium dense, brown, moist, Stratified, no HCl reaction Length Recovered 0.8 ft, Length Retained 0.8 ft		
25										
	8									
				5 8 13 (21)		D-6	GS MC	SM, MC=17% Silty SAND, medium dense, olive brown, moist, Stratified, no HCl reaction Length Recovered 0.9 ft, Length Retained 0.9 ft		
30	9									
	10			7 13 13 (26)		D-7		Poorly graded SAND, dense, olive brown, moist, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
35	11								▽ 07/03/2001	
				14 16 15 (31)		D-8		Poorly graded SAND, dense, olive brown, wet, Stratified, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
	12									
40										
	13		>>	12 27 39 (66)		D-9		Poorly graded SAND with gravel, very dense, olive gray, moist, Stratified, no HCl reaction Length Recovered 0.9 ft, Length Retained 0.9 ft		
45										

SOIL XL-1217 SR-28 EAST WENATCHEE-CANAL.GPJ SOIL.GDT 3/29/05 2:06:15 P3

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-04731

Job No. XL-1217 SR 28 Elevation 850.5 ft (259.2 m)

HOLE No. H-1-01

Sheet 3 of 3

Project East Wenatchee Canal Crossing-Box Culvert.

Driller Fetterly Lic# 2507

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14							End of test hole boring at 44.5 ft below ground elevation.		
								This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
50	15									
	16									
55	17									
	18									
60	19									
65	20									
	21									
70										

SOIL XL-1217 SR-28 EAST WENATCHEE-CANAL.GPJ SOIL.GDT 3/29/05 2:06:15 P3

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-04731

HOLE No. H-2-01

Job No. XL-1217 SR 28 Elevation 852.5 ft (259.8 m)

Sheet 1 of 2

Project East Wenatchee Canal Crossing-Box Culvert. Driller Fetterly Lic# 2507

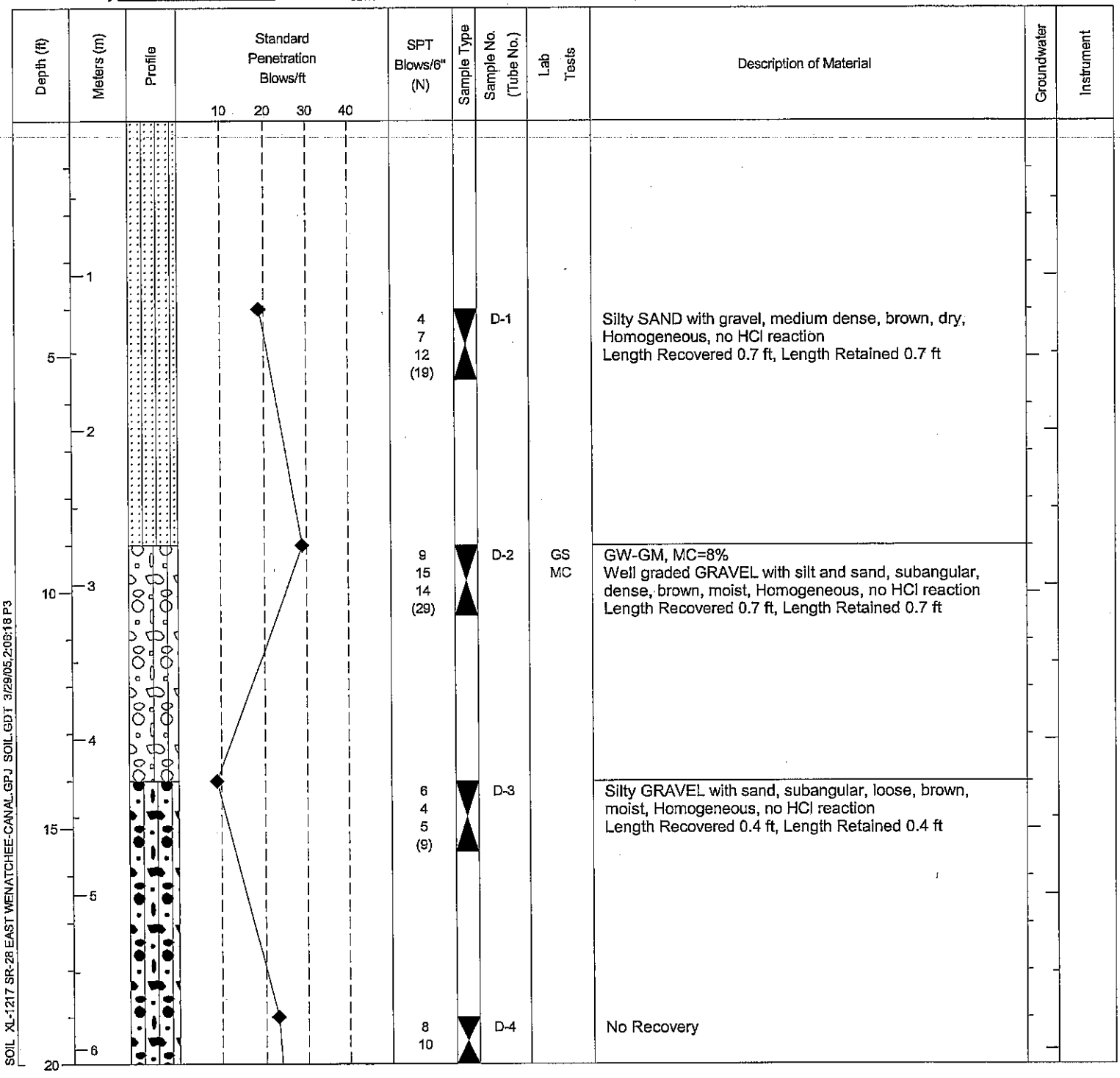
Site Address Inspector Hanning

Start July 3, 2001 Completion July 3, 2001 Well ID# NA Equipment CME 850 w/ autohammer

Station 151+35 Offset 53.5' Lt. Casing HQ Method Wet Rotary

Northing 494773.279 Easting 2101103.781 Latitude Longitude

County Douglas Subsection NE/SW Section 26 Range 20EWM Township 23N



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Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-04731

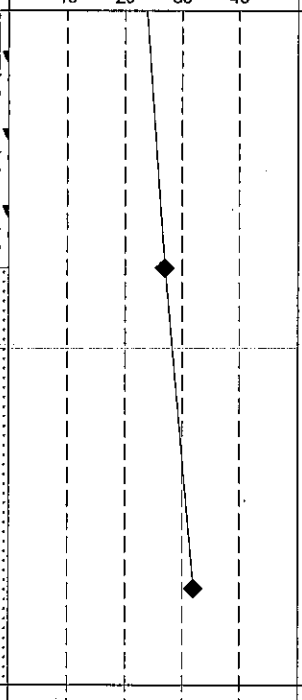
Job No. XL-1217 SR 28 Elevation 852.5 ft (259.8 m)

HOLE No. H-2-01

Sheet 2 of 2

Project East Wenatchee Canal Crossing-Box Culvert.

Driller Fetterly Lic# 2507



Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
		13 (23)						
	7							
		25 15 12 (27)		D-5		Poorly graded SAND with gravel, dense, olive brown, moist, Stratified, no HCl reaction, Note drilling indicates change at 22' to sand, some gravel. Length Recovered 0.6 ft, Length Retained 0.6 ft		
25	8					07/03/2001	▽	
		7 16 16 (32)		D-6	GS MC	SP-SM, MC=16% Poorly graded SAND with silt, dense, olive brown, moist, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
30	9					End of test hole boring at 30.5 ft below ground elevation.		
	10					This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
35	11							
	12							
40								
	13							
45								

SOIL XL-1217 SR-28 EAST WENATCHEE-CANAL.GPJ SOIL.GDT 3/29/05 2:06:19 P3

APPENDIX - C

Laboratory Test Data

Job No. **XL-1217** Date **March 29, 2005**

Hole No. **H-1-01** Sheet **1** of **2**

Project **East Wenatchee Canal Crossing-Box Culvert.**

Laboratory Summary

Washington State Department of Transportation

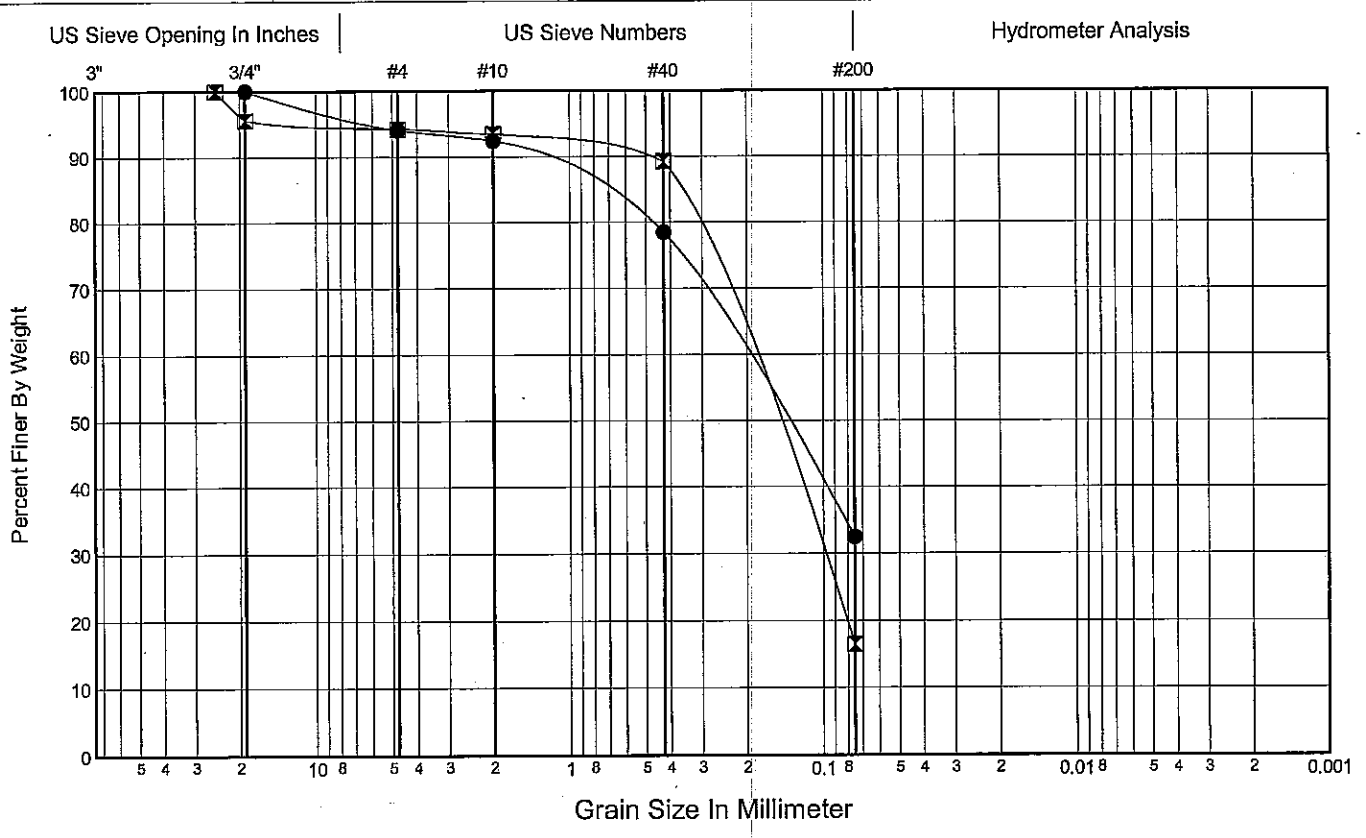
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	8.0	2.44	D-2	SM	See Boring Log	SILTY SAND	21			
⊠	28.0	8.53	D-6	SM	See Boring Log	SILTY SAND	17			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	6.0	61.6	32.4		
⊠	5.8	77.8	16.4		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.212	0.15			
⊠	0.212	0.17	0.10	0.08	



Job No. **XL-1217** Date **March 29, 2005**

Hole No. **H-2-01** Sheet **2** of **2**

Project **East Wenatchee Canal Crossing-Box Culvert.**

Laboratory Summary

Washington State Department of Transportation

	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	9.0	2.74	D-2	GW-GM	See Boring Log	WELL-GRADED GRAVEL with SILT and SAND	8			
☒	29.0	8.84	D-6	SP-SM	See Boring Log	POORLY GRADED SAND with SILT	16			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	59.1	35.3	5.6	1.5	107.5
☒	8.9	80.3	10.8	0.8	4.0

GRADATION VALUES

	D60	D50	D30	D20	D10
●	14.591	8.11	1.72	0.51	0.136
☒	0.297	0.22	0.13	0.10